Systematic Review

Comparison of the Efficacy of Single-Injection Regional Analgesia Techniques for Total Abdominal Hysterectomy: A Systematic Review and Network Meta-Analysis

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Background: Single-injection regional analgesia techniques can provide effective analgesia for abdominal hysterectomy. However, few randomized controlled trials (RCTs) have directly compared these techniques for total abdominal hysterectomy (TAH), and the best strategy remains unknown.

Objectives: In this network meta-analysis, we compared the analgesic efficacy of single-injection regional analgesia techniques in patients who underwent TAH.

Study Design: A systematic review and network meta-analysis.

Methods: We searched the PubMed, Embase, Cochrane, and CINAHL databases for relevant trials from inception until April 2022. RCTs that examined single-injection regional analgesia techniques for TAH were included. Random-effects network meta-analyses were performed using the frequentist approach. The primary outcome was 24-hour cumulative morphine equivalent consumption. The secondary outcomes were pain scores, time to first request for rescue analgesia, and rates of postoperative nausea and vomiting (PONV).

Results: In total, 36 RCTs were included. Network meta-analyses indicated that the erector spinae plane block provided superior analgesia in terms of reduced morphine consumption, low PONV incidence, and longer time to first analgesia request. Moreover, compared with control (i.e., sham or placebo), the quadratus lumborum block provided superior analgesia in terms of time to first analgesia request and resting pain scores.

Limitations: (1) Few studies have examined single-injection regional analgesia techniques other than the transversus abdominis plane block (TAPB) and wound infiltration, leading to a few indirect effect estimates. (2) Heterogeneity existed due to analgesic type/dose, plane block timing, and injection site. (3) Objective outcomes, such as length of hospital stay, were lacking; most studies only included the patient-reported subjective pain score.

Conclusion: Single-injection blocks are effective analgesic techniques for TAH. Among them, the erector spinae plane block and quadratus lumborum block seem to have superior effects. Further studies should evaluate techniques other than TAPB and wound infiltration to draw definitive conclusions.

Key words: Single-injection regional analgesia, total abdominal hysterectomy, transversus abdominis plane block, quadratus lumborum block, erector spinae plane block, rectus sheath block, wound infiltration, morphine consumption, postoperative nausea and vomiting, network meta-analysis

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Hysterectomy is the most frequently performed gynecological surgery. Despite the advance of minimally invasive surgeries, total abdominal hysterectomy (TAH) is still required in patients with a large uterus or extensive adhesions (1). In the United States, 54.1% of hysterectomies were performed through TAH in 2010 (2). TAH is associated with a higher postoperative pain score, averaging 6 of 10 (3). Inadequate pain control in patients with TAH may lead to lower patient satisfaction, higher financial costs, and longer hospital stays (4). Moreover, patients with TAH have several inevitable risk factors for postoperative nausea and vomiting (PONV), and they are more vulnerable to PONV if higher doses of opioids are required as rescue analgesia (2,5,6).

Regional anesthesia reduces postoperative pain intensity and consequent opioid consumption (7,8). Enhanced recovery programs after gynecological surgeries have also suggested that regional anesthesia should be incorporated into the multimodal analgesia strategy (4). With advancements in ultrasound techniques, various abdominal peripheral nerve blocks have been evaluated in TAH, with promising analgesic efficacy and safety. Abdominal peripheral nerve block precisely targets the nerves innervating the surgical incision and provides prolonged analgesia compared with wound infiltration (WI); in this nerve block, local anesthetic is administered in the subdermal and musculofascial region, avoiding the rare but detrimental complications of neuraxial anesthesia (9-14).

Among the various regional anesthesia techniques for hysterectomy, only transversus abdominis plane block (TAPB) has been compared with no block or saline placebo in meta-analyses (15-18). Studies have combined laparoscopic, robotic, and abdominal hysterectomies due to data sparsity (15-18). However, the dissimilar location and length of the incisional wound can significantly influence the efficacy of TAPB and lead to misleading conclusions. Moreover, previous reviews have failed to include randomized controlled trials (RCTs) evaluating other regional anesthesia techniques due to the statistical limitation of pairwise meta-analysis (15-18). Therefore, the analgesic effect of different regional anesthesia methods, such as peripheral nerve blocks, plexus blocks, muscle plane blocks, fascial plane blocks, or WI in TAH, remains unclear.

Because of the uncertainties of optimal regional anesthesia technique for TAH, we conducted a systematic review and network meta-analysis of RCTs by pooling all available data to evaluate the efficacy and safety of different regional anesthesia techniques among patients who underwent TAH.

Methods

Inclusion and Exclusion Criteria

We included RCTs that examined the effects of truncal blocks on patients who underwent TAH. We used the following participant, intervention, comparison, and outcome (PICO) components to establish inclusion criteria: (1) P: patients who underwent TAH; (2) I: single-injection regional analgesia techniques, such as TAPB, quadratus lumborum block (QLB), erector spinae plane block (ESPB), rectus sheath block (RSB), paravertebral block, transversalis fascia block, and WI; (3) C: sham block (mock block), placebo (block with saline); (4) O: analgesic effects, such as cumulative morphine consumption.

The exclusion criteria were as follows: (1) participants did not receive TAH but received cesarean section and laparoscopic/robotic hysterectomy; (2) participants did not receive single-injection regional analgesia techniques but received continuous wound infusion or epidural infusion; (4) analgesic effects were not compared—for example, comparison of doses and adjuvants to plane blocks; (5) nonparallel RCTs; and (6) conference abstract only.

Search Strategy and Study Selection

Two authors (GHB and MCT) independently searched the PubMed, Embase, Cochrane, and CINAHL databases for relevant trials from inception until May 2022. The following keywords were used: ("abdominal hysterectomy" OR "total abdominal hysterectomy" OR

"open hysterectomy") AND ("nerve block" OR "peripheral nerve block" OR "truncal plane block" OR "truncal nerve block" OR "transversus abdominis plane block" OR "quadratus lumborum block" OR "erector spinae plane block" OR "rectus sheath block" OR "paravertebral block" OR "transversalis fascia block" OR "wound infiltration" OR "surgical site infiltration").

Search Outcome and Data Abstraction

The 2 reviewers (GHB and MCT) independently evaluated the titles and abstracts. Data were extracted by the same 2 reviewers. Information on the following characteristics was collected for each trial: first author, publication year, country, number of participants, intervention technique/dose, comparison, timing, postoperative analgesics, outcomes, and information regarding the assessment of bias risk. Disagreements were resolved by the third reviewer (WHH).

Outcome Measures

The primary outcome was 24-hour cumulative morphine equivalent consumption. All opioid consumption data were converted to intravenous morphine equivalents (milligrams) using standardized conversion tables from the British National Formulary.

The secondary outcomes were time to first analgesia request, 6–8-hour postoperative pain score, 24-hour postoperative pain score, and PONV incidence. The time to first analgesia request was recorded in hours. Pain scores were assessed using the visual analog scale and numeric rating scale rating from 0 to 10 in the included studies. Pain scores were assessed for 6-8 hours postoperatively and 24 h after TAH in this review.

Methodological Quality Appraisal and Certainty of Evidence

The two reviewers (GHB and MCT) independently assessed the methodological quality by using the revised Cochrane Risk of Bias 2.0 (RoB 2.0) tool for RCTs, which assesses bias arising from the randomization process, deviation from intended interventions, missing outcome data, outcome measurement, and selection report (19). The decisions of the 2 reviewers were compared, and disagreements were resolved through consultation with a third reviewer (WHH).

Moreover, the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) evidence profile was used to assess the certainty of evidence (20). The primary outcome subjected to the network meta-analysis was rated for risk of bias, inconsistency, indirectness, imprecision, publication bias, and overall grade of evidence quality with the aid of Confidence in Network Meta-Analysis (CINeMA) (21).

Data Synthesis and Analysis

Network Meta-analysis

To visualize network geometry and node connectivity, we produced network plots for each outcome. The network geometry demonstrates the number of unique treatments and how frequently they are evaluated as well as the comparisons between different treatments. Network plots weighted nodes by the number of studies, including the corresponding treatment, and weighted connections by the number of studies comparing the 2 connected nodes. We performed the frequentist framework random-effects network meta-analysis using RStudio software version 1.4.1717 (https://www.rstudio.com/) in the netmeta package (22). We presented the mean difference and standardized mean difference with a 95% confidence interval (CI) for continuous outcomes in league tables. For PONV incidence, an odds ratio (OR) with 95% CI was calculated. We also presented the summary treatment effects of single-injection regional analgesia techniques compared with the control group with 95% CI in forest plots; differences were considered statistically significant at P values < 0.05. Furthermore, we demonstrated the network meta-analysis ranking of all interventions by calculating the P score (22). The highest and lowest P scores indicated the best and worst treatments, respectively.

Heterogeneity and inconsistency were assessed for each outcome network by using the I^2 and Cochran's Q statistics. Cochran's Q and the corresponding P value were reported for the model's total heterogeneity/inconsistency, within-design heterogeneity, and between-design inconsistency. The inconsistency between direct and indirect evidence was assessed using global and local inconsistency tests (23,24). Local inconsistency was assessed using the back-calculation method to split the contribution of direct and indirect evidence in network meta-analysis (25); $P < 0.05$ indicated significant inconsistency. Plots showing the percentage of direct and indirect evidence used for each separate network meta-analysis were also generated. The minimal parallelism and the mean path length of each comparison were also calculated. According to König et al, lower values of minimal parallelism and the mean path length > 2 indicate that the results of a specific comparison should be interpreted with caution (26).

Results

Study Selection

We retrieved relevant publications from the PubMed (n = 120), Embase (n = 178), Cochrane (n = 141), and CINAHL (n = 51) databases. After duplicates and trial protocols were excluded, 259 studies remained. Of them, 185 were excluded after title and abstract screening and another 38 after full-text assessment (Fig. 1), leaving 36 studies for analysis.

Study Characteristics

The 36 studies were published between 1995 and 2022, with sample sizes ranging from 30 to 105 (total participants: 1916). The analgesic effects of WI, ESPB, QLB, RSB, ilioinguinal nerve block (IINB), and superior hypogastric plexus block (SHPB) were evaluated in 10 (27-36), 3 (37-39), 3 (40-42), 2 (43,44), 2 (45,46) and 2 (47,48) studies, respectively. The other 14 studies evaluated the effects of TAPB (49-62), with 7 using the lateral approach (49,51,53,56,58,61,62), 6 adopting the posterior approach (50,52,54,55,59,60), and one employing the subcostal approach (57). Most trials used general anesthesia, but 3 administered spinal anesthesia (38,41,62). Moreover, the regional analgesia technique used was only a single injection without continuous catheter use.

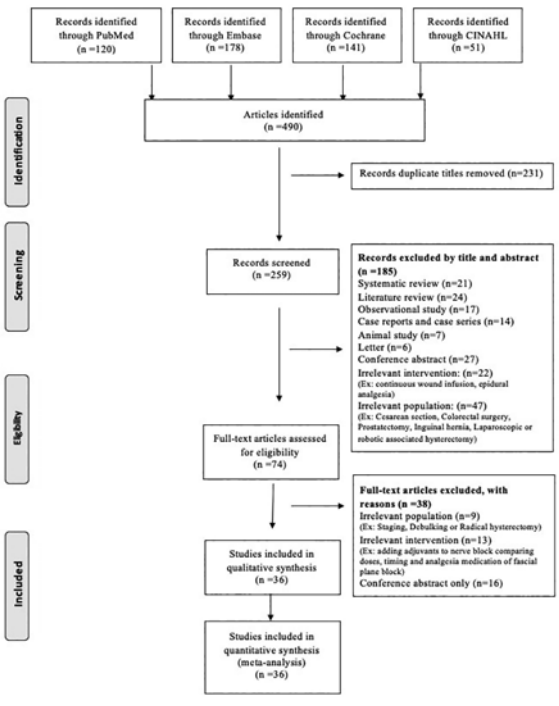

Fig. 1. *PRISMA flow chart of studies identification, screening, and included process.*

The baseline characteristics and demographic features are listed in Supplemental Tables 1 and 2, respectively. Given inadequate results and potential clinical heterogeneity from the studies of IINB (45,46), we did not evaluate the analgesic efficacy of IINB in our network meta-analyses. Supplemental Table 3 presents the quality of the included trials using RoB 2.0.

Synthesis of Results from Network Meta-analysis

Cumulative Morphine Consumption at 24 hours

Cumulative morphine consumption at 24 hours was reported in 20 trials (27-29,31,35-39,42-44,49,51,53-56,60,61). The network plot illustrated one direct estimated comparison, 7 mixed estimated comparisons, and 7 indirect estimated comparisons (Fig. 2). Nine studies had a low overall risk of bias (Supplemental Table 3). Most comparisons were graded as having moderate confidence, and imprecision was the most common reason for downgrading. In addition, the CINeMA level was assessed for each comparison of the primary outcome in Supplemental Table 4.

ESPB (MD = –11.57 mg, 95% CI = –20.16, –2.98), TAPB (MD = –6.51 mg, 95% CI = –11.76, –1.26), and WI (MD = –6.23 mg, 95% CI = –12.11, –0.36) significantly reduced total 24-hour opioid consumption compared with the control groups; however, no significant effects were found in the QLB and RSB groups (Fig. 3A). A league table for the primary outcome is presented in Table 1. The random-effects ranking based on point estimates were used to rank the treatments in the following order (as shown in Table 2): ESPB (#1 *P*-score = 0.8269), QLB (#2 *P*-score = 0.7295), TAPB (#3 *P*-score = 0.5418), WI (#4 *P*-score = 0.5270), and RSB (#5 *P*-score = 0.2766).

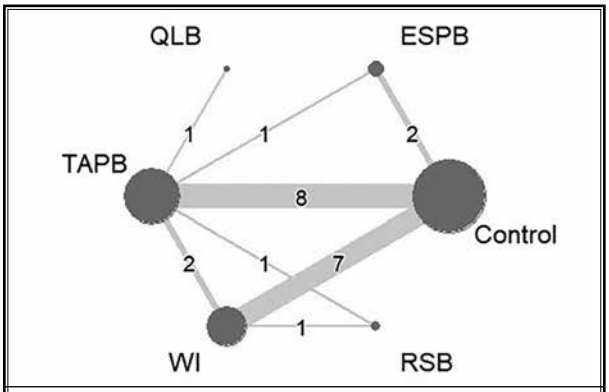

Fig. 2. *Network plot for cumulative intravenous morphine-equivalent consumption at 24 h.*

Table 1. *Network league table for all the interventions in regard to cumulative morphine-equivalent consumption at 24 h, pain scores (6-8 h postoperatively), pain scores (24 h postoperatively), time to first rescue analgesia, and incidence of nausea and vomiting. The significant results are in bold type. *Both left triangle and right triangles of the Table are read top left: bottom right.*

	ESPB	**3.89 (1.00, 6.77)**	**8.14 (5.72, 10.55)**	**9.90 (6.66, 13.13)**	**10.20 (6.22, 14.17)**	**10.59 (8.20, 12.97)**		
	-0.66 (-17.83, 16.52)	**QLB**	**4.25 (2.53, 5.97)**	**6.01 (3.18, 8.84)**	**6.31 (2.71, 9.91)**	**6.70 (4.91, 8.49)**		
Cumulative 24 h morphine-equivalent consumption [MD]	-5.06 (-14.16, 4.04)	-4.40 (-18.96, 10.16)	**TAPB**	1.76 (-0.66, 4.18)	2.06 (-1.10, 5.22)	**2.45 (1.43, 3.47)**		**Time to first required analgesia [MD]**
	-5.34 (-15.53, 4.86)	-4.68 (-20.84, 11.48)	-0.28 (-7.28, 6.72)	**WI**	0.30 (-3.68, 4.28)	0.69 (-1.50, 2.88)		
	-9.58 (-24.26, 5.11)	-8.92 (-27.76, 9.93)	-4.52 (-16.48, 7.44)	-4.24 (-16.75, 8.27)	**RSB**	0.39 (-2.93, 3.71)		
	-11.57 (-20.16, -2.98)	-10.91 (-26.39, 4.57)	**-6.51 (-11.76, -1.26)**	**-6.23 (-12.11, -0.36)**	-1.99 (-14.46, 10.47)	**Control**		
	QLB	5.55 (0.7, 50)	1.54 (0.47, 5.26)	0.97 (0.21, 4.58)	1.89 (0.48, 7.69)	0.27 (0.04, 2.03)	0.95 (0.28, 3.25)	
	-1.92 (-3.41, -0.42)	**ESPB**	0.27 (0.05, 1.52)	0.17 (0.02, 1.27)	0.33 (0.05, 2.15)	**0.05 (0.00, 0.51)**	**0.17 (0.03, 0.98)**	
	-2.17 (-3.17, -1.16)	-0.25 (-1.41, 0.91)	**TAPB**	0.63 (0.22, 1.75)	1.22 (0.60, 2.5)	**0.18 (0.03, 0.89)**	**0.61 (0.40, 0.93)**	
6-8 h Pain scores [SMD]	**-2.29 (-3.77, -0.81)**	-0.37 (-1.86, 1.11)	-0.12 (-1.27, 1.02)	**SHPB**	1.96 (0.61, 6.25)	0.28 (0.04, 1.86)	0.98 (0.38, 2.50)	Incidence of nausea and vomiting [Odds ratio]
	-2.88 (-4.11, -1.65)	-0.97 (-2.21, 0.28)	-0.72 (-1.50, 0.06)	-0.59 (-1.83, 0.64)	**WI**	**0.14 (0.03, 0.74)**	**0.50 (0.25, 0.98)**	
	-3.04 (-4.83, -1.24)	-1.12 (-3.00, 0.76)	-0.87 (-2.35, 0.61)	-0.75 (-2.62, 1.13)	-0.15 (-1.83, 1.52)	**RSB**	3.44 (0.68, 16.67)	
	-3.12 (-4.17, -2.07)	**-1.20 (-2.26, -0.15)**	**-0.95 (-1.43, -0.48)**	-0.83 (-1.87, 0.21)	-0.24 (-0.90, 0.43)	-0.08 (-1.64, 1.47)	**Control**	
	QLB							
	-1.49 (-2.80, -0.18)	**TAPB**						
	-1.94 (-3.87, 0.00)	-0.44 (-1.94, 1.06)	**SHPB**					
24 h Pain scores [SMD]	**-2.04 (-3.98, -0.10)**	-0.55 (-2.05, 0.95)	-0.10 (-2.05, 1.84)	**ESPB**				
	-2.11 (-4.04, -0.17)	-0.61 (-2.11, 0.89)	-0.17 (-2.12, 1.78)	-0.07 (-2.01, 1.88)	**WI**			
	-2.37 (-3.74, -1.01)	**-0.88 (-1.48, -0.29)**	-0.44 (-1.81, 0.94)	-0.33 (-1.71, 1.04)	-0.27 (-1.64, 1.11)	**Control**		

Time to First Analgesia Request

The time to first analgesia request was investigated in 14 trials (29,38-43,50,52,55,56,59,60,62). The network plot revealed 2 direct estimates, 5 mixed estimates, and 8 indirect estimates (Supplemental Fig. 1A). The ESPB, QLB, and TAPB groups exhibited a significantly prolonged time to request analgesia compared with the control group; only the WI and RSB were not significantly superior to the control (Fig. 3B). *P*-score ranking was in the following order: ESPB, QLB, TAPB WI, and RSB (Table 2). Moreover, a league table showed that ESPB and QLB were effective single-injection regional analgesia techniques, which had significantly longer time to first analgesia request than the TAPB, WI, or RSB (Table 1).

Pain Scores (6–8-hours After TAH)

Pain scores of 6–8 hours were reported by 16 trials on TAH (Supplemental Fig. 1B) (32,34,37,38,41-43,51,53-60). Six of them showed low risk regarding the overall risk of bias (Supplemental Table 3). Among the 3 direct estimated comparisons, 5 mixed estimated comparisons, and 13 indirect estimated comparisons of our resulting network, QLB (SMD = –3.12, 95% CI = –4.17, –2.07), ESPB (SMD = –1.20, 95% CI = –2.26, –0.15), and TAPB (SMD = –0.95, 95% CI = –1.43, –0.48) significantly reduced 6–8-hour pain scores compared with the control (Fig. 3C). On the basis of point estimated ranking, QLB was the most effective analgesic technique (Table 2), which resulted in significant postoperative 6–8-hour pain score reduction compared with ESPB, TAPB, SHPB, WI, and RSB (Table 1).

Pain Scores (24 hours after TAH)

Pain scores 24 hours after TAH were evaluated in 14 trials (37,38,41,42,51,53-61). Of them, 7 studies had a low overall risk of bias (Supplemental Table 3). The network plot revealed three direct comparisons, 3 mixed estimated comparisons, and 9 indirect estimated comparisons (Supplemental Fig. 1C). QLB (SMD = –2.37. 95% CI = –3.74, –1.01) and TAPB (SMD = –0.88, 95% CI = –1.48, –0.29) were significantly superior to the control (Fig. 3D). Moreover, compared with other single-injection regional analgesia techniques, QLB had the most significant analgesic efficacy in reducing pain scores 24 hours after surgery (Table 1).

Incidence of Postoperative Side Effects

The incidence of postoperative side effects, including PONV, was reported in 16 trials (29,36,39-41,43,44,52,53,55,56,58-62), and the incidence varied among these 16 trials. The network plot indicated 2 direct estimates, 7 mixed estimates, and 12 indirect estimates (Supplemental Fig. 1D). Most included studies did not report PONV together; thus, we collected the results for only vomiting from studies that reported nausea and vomiting separately to avoid duplication. ESPB, WI, and TAPB had significant effects on the reduction of PONV compared with the control (ESPB: odds ratio [OR] = 0.17, 95% CI = 0.03, 0.98; WI: OR = 0.50, 95% CI = 0.25, 0.98; and TAPB: OR = 0.61, 95% CI = 0.40, 0.93); moreover, the league table also revealed that ESPB, WI, and TAPB reduced PONV incidence compared with the RSB group (Table 1).

Exploration of Inconsistency

Heterogeneity and inconsistency tests and the back-calculation method were used to estimate direct and indirect evidence across all outcomes, and the results are demonstrated in Supplemental Figs. 2-6. The direct evidence proportion for each network estimate across all outcomes is highlighted in Supplemental Figs. 7-11.

Regarding the network model for the primary outcome, tests for heterogeneity using Cochran's Q de-

Table 2. *P-scores estimates for all the interventions.*

	24-h morphine-equivalent consumption Rank (*P*-score)	Time to first rescue analgesia Rank (*P*-score)	6-8 h Pain scores Rank (*P*-score)	24 h Pain scores Rank (*P*-score)	Incidence of nausea and vomiting Rank (*P*-score)
ESPB	#1 (0.8269)	#1 (0.9992)	#2 (0.6937)	#4 (0.3848)	#1 (0.9472)
QLB	#2 (0.7295)	#2 (0.8008)	#1 (0.9987)	#1 (0.9852)	#4 (0.4025)
TAPB	#3 (0.5418)	#3 (0.5645)	#3 (0.6264)	#2 (0.6562)	#3 (0.6511)
SHPB	-	-	#4 (0.5463)	#3 (0.4301)	#5 (0.3784)
WI	#4 (0.5270)	#4 (0.2735)	#5 (0.2667)	#5 (0.3564)	#2 (0.7488)
RSB	#5 (0.2766)	#5 (0.2266)	#6 (0.2394)	-	#7 (0.0497)
Control	#6 (0.0982)	#6 (0.1355)	#7 (0.1287)	#6 (0.1873)	#6 (0.3224)

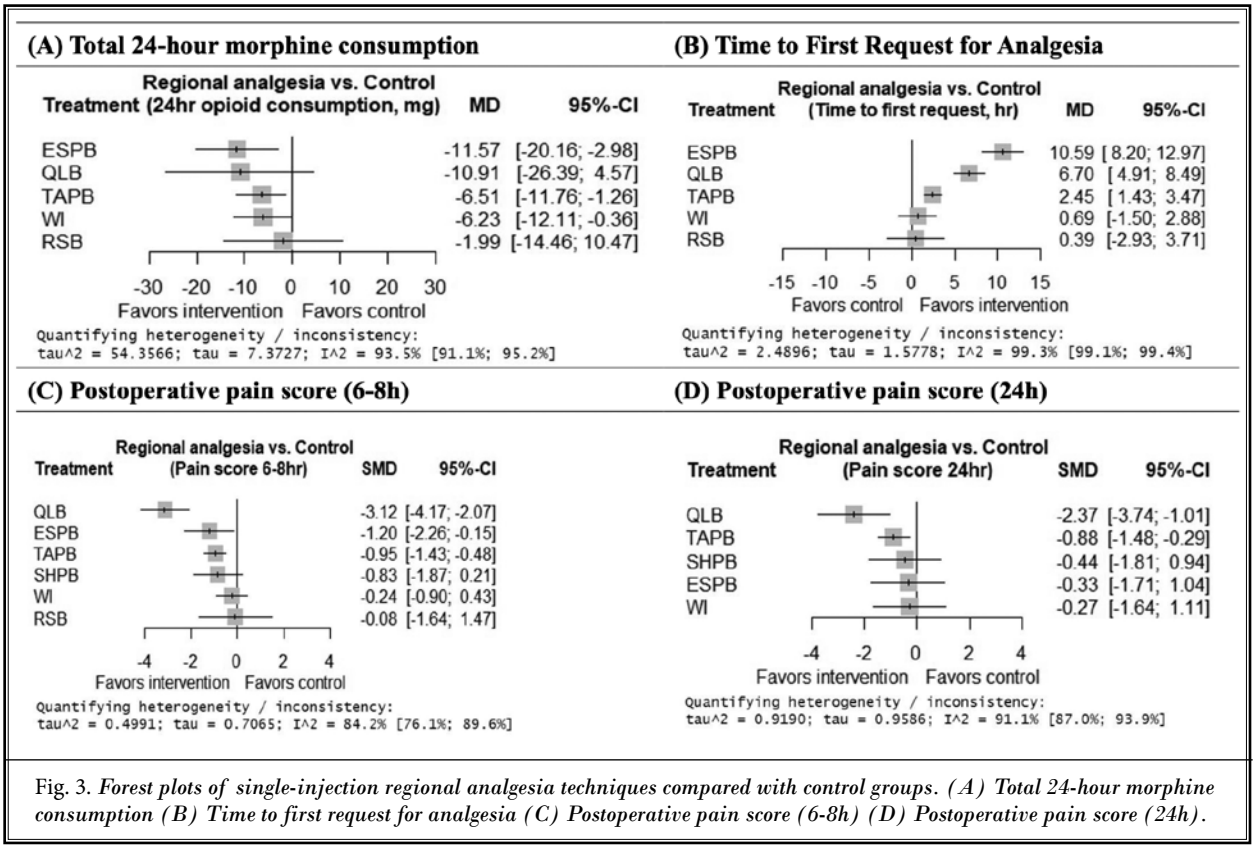

Fig. 3. *Forest plots of single-injection regional analgesia techniques compared with control groups. (A) Total 24-hour morphine consumption (B) Time to first request for analgesia (C) Postoperative pain score (6-8h) (D) Postoperative pain score (24h).*

termined a within-design Q value of 182.02 ($P<0.0001$), and the test for between-design inconsistency estimated a Q value of 78.27 ($P<0.0001$). The local approach to the assessment of inconsistency identified no significant disagreement between direct and indirect estimate comparisons regarding the primary outcome (Supplemental Fig. 2).

Discussion

Previous systematic reviews and meta-analyses have focused only on the analgesic effects of TAPB compared with controls in patients who underwent TAH (16). Our study is the first network meta-analysis to investigate the efficacy of different regional anesthesia techniques. This systematic review and network meta-analysis revealed that ESPB, TAPB, and WI significantly reduced total 24-hour opioid consumption compared with the control. The ESPB, QLB, and TAPB groups exhibited a significantly prolonged time to the first analgesic compared with the control group. The QLB, ESPB, and TAPB significantly reduced 6–8-hour pain scores, with the QLB providing the lowest pain score at 24 hours compared with other regional analgesia techniques. Additionally, ESPB, TAPB, and WI had significant effects on reducing the risk of PONV compared with the control. No serious adverse effects related to regional anesthesia techniques were reported.

Although the exact mechanisms of the prolonged analgesia of ESPB and QLB remain speculative (63), our findings suggest that ESPB and QLB have better effects than other single-injection regional analgesia, whereas RSB seems to have the least analgesic effect. A pairwise meta-analysis comparing QLB and TAPB demonstrated that QLB showed more effective analgesia than TAPB in regard to opioid consumption, VAS scores, and rescue analgesics in different abdominal surgeries (64,65). The pain from TAH originates from both somatic and visceral incisions. TAPB targets mainly somatic pain of the anterolateral abdominal wall of T7-L1, and QLB not only covers the somatic dermatomes from T7 to L1 (64) but also exhibits an analgesic effect on visceral pain by blocking the sympathetic neurons between the thoracolumbar fascia and through the paravertebral spread of local anesthetics (66). Blockage of sympathetic nerve fibers that have a strong vasomotor component can lead to a change in local circulation and autonomic tone and can further provide better analgesic efficacy for postoperative pain (12).

Regarding ESPB, most systematic reviews have evaluated thoracic, breast, and spine surgeries. Only one meta-analysis of ESPB in abdominal surgeries was conducted and concluded that ESPB, compared with the control, was associated with reduced opioid consumption and prolonged time to first analgesic, but it provided no benefit for pain scores and PONV incidence (67). However, the meta-analysis might have underestimated the analgesic effect of ESPB by including minimally invasive surgeries that have lower postoperative pain. The mechanisms of ESPB remain controversial. The largest anatomical studies available suggest that ESPB results in the spread of local anesthetics in the thoracic paravertebral space when a sufficient volume is injected (68). Although based on speculation, the superior analgesic effect of ESPB in this study might result from more intense postoperative pain in TAH and the analgesic effect against visceral pain through the paravertebral spread. Further studies should be conducted to determine the mechanism of ESPB in abdominal surgeries and the optimal volume of ESPB at different levels of injection.

Prophylactic PONV management is an integral aspect of enhanced recovery pathways. According to the consensus guideline of PONV management, perioperative regional anesthesia is effective in reducing baseline PONV risk by reducing opioid consumption and should be applied whenever feasible (5,69). Previous meta-analyses have concluded that regional anesthesia provides significant PONV reduction effects (70-72). However, many factors significantly influence the PONV-reducing effect of regional anesthesia, such as surgery types, patient background, organ involvement, and pain intensity, etc. (5). Our study focused only on patients undergoing TAH for benign lesions, and the results revealed that ESPB, WI, and TAPB had significant effects on the reduction of both 24-hour opioid consumption and PONV incidence and that they can contribute to evidence-based ERAS pathways.

Two included studies evaluated the effects of SHPB (47,48). Although SHPB had a nonsignificant analgesic effect compared with the control, it appears to be a unique and promising method for alleviating acute postoperative pain in TAH by relieving visceral pain instead of somatic pain. When combined with somatic nerve block techniques, SHPB can contribute to more effective pain relief and PONV reduction; however, further studies are warranted (47,48).

Heterogeneity

For our primary outcome, tests for heterogeneity determined a within-design Q value of 182.02 ($P<0.0001$), and the test for between-design inconsistency revealed a Q value of 78.27 ($P<0.0001$). The heterogeneity within design might be due to inconsistencies in study design, analgesic type/dose, plane block timing, and injection site. Between-design inconsistency was further assessed using a local inconsistency test, which revealed no significant difference between direct and indirect evidence.

Strengths and Limitations

This meta-analysis has several advantages. First, an extensive search of RCTs published from inception to 2022 was conducted, with numerous participants and populations from various parts. Although a 2019 meta-analysis focused on TAPB with control (16), our study is the first network meta-analysis to investigate the efficacy of different regional anesthesia techniques. Second, we focused on TAH for benign lesions, excluding laparoscopic/robotic hysterectomy, malignant lesions, and neuraxial analgesia, to decrease clinical heterogeneity. Third, our study included various outcomes of analgesic efficacy, such as 24-hour opioid consumption, time to first analgesia request, and postoperative pain scores.

This study has several limitations. First, except for TAPB and WI, few articles were available on other single-injection regional analgesia techniques, leading to a few indirect effects estimates of our network meta-analysis. Second, heterogeneity existed due to analgesic type/dose, plane block timing, and injection site; however, our network meta-analysis revealed coherent results between direct and indirect comparisons. Finally, an objective outcome measure of patients' postoperative recovery is lacking (e.g., the time to get out of bed, discharge time, and cost-effectiveness analysis) because most studies only included the subjective pain score reported by patients. Further research into single-injection regional analgesia techniques other than TAPB and WI for TAH is necessary.

Conclusions

Single-injection regional anesthesia has contributed to multimodal opioid-sparing analgesia in TAH. ESPB and QLB seemed to have superior effects to the other approaches. However, modest evidence was available regarding single-injection regional analgesia techniques other than TAPB and WI, suggesting that these data should be interpreted with caution.

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Authors' Contributions

GHB, MCT, TYH, YNK, and WHH designed the research; GHB, MCT, and TYH conducted the research; GHB, MCT, and TYH analyzed the data; GHB, MCT, and TYH wrote the manuscript; and TYH and WHH reviewed the final manuscript. This manuscript was edited by Wallace Academic Editing.

Availability of Data, Material, and Code

Data described in the manuscript, code book, and analytic code will not be made available because this study is a secondary data analysis from 36 previously published randomized controlled trials.

Supplementary material available at www.painphysicianjournal.com

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Supplemental Table 1. *Characteristics and outcome summary of included studies.*

Author year	Sample size	Intervention technique	Intervention dosage and local anesthetics	Comparison	Timing	Postoperative analgesic	Outcome	Outcome summary
Amr 2011(1) Egypt	TAPB before: 23 TAPB after: 23 Control: 22	TAPB: U/S-guided, Bilateral posterior approach	20 mL, 0.375% bupivacaine	Control: Needle punctures	Before & End	1. IV morphine 20-50 mcg/kg	1. VAS scores 2. Time to first rescue 3. N/V	1. Lower in TAPB 2. Longer in TAPB 3. TAPB (16%, 29%); control (66.5%)
Atim 2011(2) Turkey	TAPB: 18 Control: 18 WI: 19	TAPB: U/S-guided, Bilateral posterior approach	20 mL, 0.25% bupivacaine	Control: 20 mL 0.9% saline WI: 20mL, 0.25% bupivacaine	End of surgery	1. IM pethidine 1mg/kg 2. PCA tramadol	1. Total 24h tramadol consumption 2. VAS scores	1. Lower in TAPB 2. Lower in TAPB at 1, 2, 4, 6, and 24h
Aytuluk 2020 (3) Turkey	SHPB: 30 Control: 30	SHPB: Fluoroscopy, retroperitoneum	30 mL, 0.25% bupivacaine	Control: No block	After removal of uterus	1. VAS > 4, Diclofenac 2. If inadequate, tramadol	1. Time to first rescue 2. VAS scores 3. N/V	1. Longer in SHPB 2. Lower in SHPB 3. No difference
Bhattacharjee 2014(4) India	TAPB: 45 Control: 45	TAPB: Landmark-guided, Bilateral posterior approach	0.5 mL/kg, 0.25% bupivacaine	Control: 0.5 mL/kg, saline	Before surgery (Before general anesthesia)	1. IV paracetamol every 6 h 2. IV tramadol 2 mg/kg	1. VAS scores 2. Time to first rescue 3. N/V	1. Lower in TAPB 2. Longer in TAPB 3. No difference
Carney 2008(5) Ireland	TAPB: 24 Control: 26	TAPB: U/S-guided, Bilateral posterior approach	1.5 mg/kg ropivacaine	Control: 0.9% saline	Before surgery	1. Rectal acetaminophen 1 g every 6h 2. Rectal diclofenac 100 mg every 16 h 3. IV PCA morphine	1. Total 24h morphine consumption 2. VAS scores 3. Time to first rescue 4. N/V	1. Lower in TAPB 2. Lower in TAPB at 4, 6, 12, 24, and 36 h 3. Longer in TAPB 4. No difference
Cobby 1996(6) UK	WI: 20 Control: 20	Wound infiltration	20 mL, 0.5% bupivacaine	Control: placebo	End of surgery	1. PCA with morphine 1 mg/mL	1. Total 24h morphine consumption	1. No difference
Erdoğan 2011(7) (SA) Turkey	TAPB: 20 Control: 20	TAPB: U/S-guided, Bilateral lateral approach	20 mL, 0.25% bupivacaine	Control: 20 mL 0.9% saline	Before surgery	1. PCEA in PACU when the patients' VAS ≥ 2	1. Time to first rescue 2. N/V	1. Longer in TAPB 2. No difference
Gasanova 2013(8) USA	TAPB: 25 Control: 25	TAPB: U/S-guided, Bilateral lateral approach	20 mL, 0.5% bupivacaine	Control: ketorolac 30 mg IV	End of surgery	1. Oral acetaminophen 650 mg every 6 h 2. PCA morphine pump	1. Total 24h morphine consumption 2. VAS scores 3. N/V	1. No difference 2. No difference 3. No difference
Gasanova 2015(9) USA	TAPB: 30 WI: 30	TAPB: U/S guided, Bilateral lateral approach	20 mL, 0.5% bupivacaine	WI: Liposomal bupivacaine 20 mL (266 mg)	End of surgery	1. VAS > 4, hydromorphone 0.1 to 0.2 mg IV bolus 2. IV-PCA morphine 3. Ketorolac 30 mg, IV, and acetaminophen 1 g, orally	1. Total 24 h morphine consumption 2. N/V	1. Lower in WI 2. No difference
Gharaei 2013(10) Iran	TAPB: 21 Control: 21	TAPB: U/S-guided, Bilateral lateral approach	0.5mg/kg, 0.2% ropivacaine	Control: No block	End of surgery	1. Fentanyl pump	1. Fentanyl flow (mL/hr) 2. VAS scores 3. Incidence of vomiting	1. No difference 2. No difference 3. No difference

Supplemental Table 1 (continued). *Characteristics and outcome summary of included studies.*

Author year	Sample size	Intervention technique	Intervention dosage and local anesthetics	Comparison	Timing	Postoperative analgesic	Outcome	Outcome summary
Hamed 2019(11) Egypt	ESPB: 30 Control: 30	ESPB: U/S-guided, Bilateral T9 approach	20 mL, 0.5% bupivacaine	Control: 20 mL, 0.9% saline	Before surgery	1. Oral acetaminophen 1 g 4 times/day 2. PCA fentanyl pump	1. Total 24 h fentanyl consumption 2. VAS scores	1. Lower in ESPB 2. Lower in ESPB at 30mins, 2, 4, 6, 12h
Hariharan 2009(12) Barbados	WI: 20 Control: 20	Wound infiltration	10 mL, 2% lidocaine + 10 mL 0.5% bupivacaine	Control: 20 mL, 0.9% saline	End of surgery	1. PCA morphine	1. Total 24h morphine consumption	1. No difference
Hayden 2017(13) Sweden	WI: 29 Control: 28	Wound infiltration	300 mg ropivacaine adrenaline 0.5 mg (5 ml)	Control: 30 mg ketorolac IV (1 mL)	End of surgery	1. Oral paracetamol 1330 mg three times daily and diclofenac 50 mg twice daily 2. NRS ≥ 3 at rest or on coughing, morphine IV 3. NRS > 6, alfentanil or fentanyl IV	1. Total 24h morphine consumption 2. Time to first rescue 3. N/V	1. Lower in WI 2. Longer in WI 3. No difference
Ismail 2021(14) Pakistan	Ismail 2021(14) Pakistan	TAPB: U/S-guided, Bilateral lateral approach	20 mL, 0.25% bupivacaine	Control: 20 mL 0.9% saline	Before surgery (After induction)	1. Rectal diclofenac 100 mg every 12 2. IV paracetamol 2g every 6 h 3. PCIA Nalbuphine pump	1. Total 24h nalbuphine consumption 2. NRS scores (No time points) 3. N/V	1. No difference 2. No difference 3. Severe N/V (score > 5): TAPB (1), Control-S (2)
Jarruwale 2016(15) Thailand	WI: 31 Control: 31	Wound infiltration	40 mL, 0.25% bupivacaine	Control: 40 mL 0.9% saline	End of surgery	1. PCA (loading dose 3 mg, PCA dose 1 mg)	1. Total 24 h morphine consumption 2. NRS scores 3. N/V	1. Lower in WI 2. Lower in WI at 1 and 2 h, no difference thereafter 3. No difference
Kamel 2020(16) Egypt	TAPB: 24 ESPB: 24	TAPB: U/S guided, Bilateral lateral approach	20 mL, 0.375% bupivacaine + 5 ug/mL adrenaline (1:200000)	ESPB: U/S-guided, Bilateral T9 approach	End of surgery	1. IV pethidine 1 mg/kg every 4 h 4. IV morphine	1. Total 24 h morphine consumption 2. VAS scores 3. Time to first rescue 4. N/V	1. Lower in ESPB 2. Lower in ESPB at 30 mins, 2, 12, 16, 20, and 24h 3. Longer in ESPB 4. No difference
Karaman 2018(17) Turkey	TAPB: 34 Control: 32	TAPB: U/S-guided, Bilateral subcostal approach	20 mL, 0.25% bupivacaine	Control: No block	Before surgery	1. Metamizole 1g every 8h 2. IV morphine 0.05 mg/kg	1. VAS scores	1. Lower in TAPB at 0, 2, 6, 12 h
Kelly 1996(18) Ireland	IINB: 20 Control: 20	IINB: Von Bahr's method	20 mL, 0.5% bupivacaine	Control: 20 mL 0.9% saline	Before surgery (Pre-incision)	1. N/A	1. VAS scores	1. No difference
Klein 2000(19) UK	WI: 20 Control: 20	Wound infiltration	40 mL, 0.25% bupivacaine	Control: 40 mL 0.9% saline	End of surgery	1. PCA morphine	1. Total 24 h morphine consumption	1. No difference

Supplemental Table 1 (continued). *Characteristics and outcome summary of included studies*.

Author year	Sample size	Intervention technique	Intervention dosage and local anesthetics	Comparison	Timing	Postoperative analgesic	Outcome	Outcome summary
Lowenstein 2008(20) Israel	WI: 16 Control: 14	Wound infiltration	20mL, 1% lidocaine	Control: 20 mL 0.9% saline	Before surgery	1. Oral ibuprofen (400 mg) at 3-h intervals 2. If further needed: 10 mg morphine	1. VAS scores	1. Lower in WI
Marais 2014(21) South Africa	TAPB: 15 Control: 15	TAPB: U/S-guided, Bilateral lateral approach	20ml, 0.25% bupivacaine	Control: 20mL 0.9% saline	Before surgery	1. Oral paracetamol 1 g every 6 h 2. indomethacin 100 mg every 12 h 3. PCA morphine pump	1. Total 24h morphine consumption 2. VAS scores 3. N/V	1. Lower in TAPB 2. No difference 3. No difference
Mathew 2019(22) India	TAPB: 20 Control: 20	TAPB: Landmark guided, Bilateral posterior approach	15 mL, 0.25% bupivacaine	Control: diclofenac IV	End of surgery (The end of procedure)	1. IV diclofenac 1 mg/kg 2. IV morphine 0.05 mg/kg	1. Total 24h morphine consumption 2. NRS scores 3. Time to first rescue 4. N/V	1. Lower in TAPB 2. Lower in TAPB at 1 and 18 h 3. Longer in TAPB 4. No difference
Mishra 2022(23) India	WI (pre-incision): 30 WI (post-closure): 30 Control: 30	Wound infiltration	40 mL, 0.25% bupivacaine	Control: No block	End of surgery	1. N/A	1. Time to first rescue 2. VAS scores	1. Longer in WI 2. Lower in WI at 24 h
Mohammad 2019(24) Egypt	TAPB: 30 RSB: 30	TAPB: U/S guided, Bilateral lateral approach	20mL, 0.25% bupivacaine	RSB: U/S guided, Bilateral	End of surgery	1. IV pethidine 0.5 mg/kg	1. Total 24h pethidine consumption 2. NRS scores 3. Time to first rescue 4. N/V	1. Lower in TAPB 2. Lower in TAPB at 6 and 8h 3. Longer in TAPB 4. Lesser in TAPB
Moyo 2016(25) Zimbabwe	TAPB: 16 Control: 16	TAPB: U/S-guided, Bilateral posterior approach	20 mL, 0.25% bupivacaine	Control: 21 mL 0.9% saline	End of surgery	1. IM pethidine 3 h prn	1. VAS scores 2. Time to first rescue	1. No difference (2, 4h) 2. Longer in TAPB
Naaz 2021(26) India	QLB: 25 TAPB: 26 Control: 25	QLB: U/S-guided, Bilateral posterior approach TAPB: U/S-guided, Bilateral lateral approach	20 mL, 0.25% bupivacaine	Control: No block	End of surgery	1. VRS > 3, diclofenac (1.5 mg/kg) 2. Not sufficient after 30 minutes, tramadol (1 mg/kg) IV 3. Still persistent after 30 minutes, morphine (0.1mg/kg) IV.	1. Time to first rescue 2. N/V	1. Longer in QLB 2. None
Prasad 2021(27) (SA) India	ESPB: 28 Control: 30	ESPB: Landmark, Bilateral T10 approach	20 mL, 0.375% ropivacaine	Control: No block	Before surgery (Before anesthesia)	1. VAS > 4, tramadol 2 mg/kg IV 2. IV paracetamol 1 gm was given post-op 8 hourly	1. Total 24h tramadol consumption 2. Time to first rescue 3. VAS score	1. Lower in ESPB 2. Longer in ESPB 3. Lower in ESPB

Supplemental Table 1 (continued). *Characteristics and outcome summary of included studies.*

Author year	Sample size	Intervention technique	Intervention dosage and local anesthetics	Comparison	Timing	Postoperative analgesic	Outcome	Outcome summary
Rapp 2016(28) Sweden	SHPB: 35 Control: 33	SHPB: Landmark, anterior to L5–S1 vertebral bodies	20 mL, 7.5 mg/mL ropivacaine	Control: 20 mL 0.9% saline	After removal of uterus	1. PCA morphine pump	1. VAS scores 2. N/V	1. Proportion of VAS < 4 higher in SHPB 2. No difference
Røjskjær 2015(29) Denmark	TAPB: 24 Control: 24	TAPB: U/S-guided, Bilateral lateral approach	20 mL, 0.75% ropivacaine	Control: 20 mL 0.9% saline	Before surgery (After induction)	1. Acetaminophen 1 g every 6h 2. Ibuprofen 600 mg every 6h 3. PCA morphine pump	1. Total 24h morphine consumption 2. VAS scores 3. N/V	1. No difference 2. Lower in TAPB at 1 and 2 h 3. No difference
Shah 2012(30) Singapore	RSB: 21 WI: 21	RSB: U/S guided, Bilateral	20 mL, 0.25% levobupivacaine	WI: 20 mL, 0.5% levobupivacaine	End of surgery	1. Morphine PCIA on demand 2. Paracetamol, 1 g/ 6 h and/or mefenamic acid, 500 mg/ 8 h	1. Total 24h morphine consumption 2. N/V	1. No difference 2. No difference
Shukula 2021(31) (SA)	QLB: 35 TAPB: 35 Control: 35	QLB: U/S-guided, Bilateral posterior approach TAPB: U/S-guided, Bilateral lateral approach	20 mL, 0.25% bupivacaine	Control: No block	End of surgery	1. VAS > 3, IM diclofenac 75 mg 2. Not sufficient, tramadol (100 mg) IV 3. Inadequate, morphine (0.1 mg/kg) IV	1. Total 24h morphine consumption 2. Time to first rescue 3. N/V	1. Lowe in WI 2. Longer in WI 3. No difference
Sinclair 1996(32) Sweden	WI: 15 Control: 15	Wound infiltration	500 mg, lidocaine	Control: placebo	End of surgery	1. Buprenorphine in doses of 0.3 mg IM	1. VAS scores	1. No difference
Suner 2019(33) Turkey	TAPB: 25 Control: 25	TAPB: U/S-guided, Bilateral lateral approach	15 mL, 0.25% bupivacaine	Control: No block	End of surgery (Surgical conclusion)	1. IM diclofenac 1.5 mg/kg 2. PCA morphine 1 mg/mL	1. Total 24h morphine consumption 2. VAS scores 3. Time to first rescue 4. N/V	1. Lower in TAPB 2. Lower in TAPB at 2, 4, 6, 12, 18, and 24 h 3. Longer in TAPB 4. No significant difference
Victory 1995(34) USA	WI: 19 Control: 19	Wound infiltration	20 mL, 0.5% bupivacaine	Control: No block	End of surgery	1. In PACU, boluses of morphine 100 pg/kg IV 2. PCA morphine IV 3. 24-hour period, hydrocodone 5 mg and acetaminophen 500 mg orally	1. Total 24h morphine consumption	1. No difference

Supplemental Table 1 (continued). *Characteristics and outcome summary of included studies*.

Author year	Sample size	Intervention technique	Intervention dosage and local anesthetics	Comparison	Timing	Postoperative analgesic	Outcome	Outcome summary
Yousef 2018(35) Egypt	TAPB: 30 QLB: 30	TAPB: U/S-guided, Bilateral lateral approach	20 mL, 0.25% bupivacaine	QLB: U/S-guided, Bilateral type 2 approach	Before surgery	1. IV morphine	1. Total 24h morphine consumption 2. VAS scores 3. Time to first rescue	1. Lower in QLB 2. Lower in QLB at 30 mins, 2, 4, 6, 12, and 24h 3. Longer in QLB
Yucel 2013(36) Turkey	IINB: 19 Control: 22	IINB: Landmark, Bilateral	4 mL, 0.5% levobupivacaine	Control: 4 mL, 0.9% saline	Before surgery	1. IV morphine	1. Total 24 h morphine consumption 2. VAS scores 3. Time to first rescue 4. Complications (nausea, vomiting)	1. Lower in IINB 2. Lower in IINB at 1, 2, 6, and 12h 3. Longer in IINB 4. No difference

Abbreviation: TAPB, transversus abdominis plane block; QLB, quadratus lumborum block; ESPB, erector spinae plane block; IINB, ilioinguinal nerve block; RSB, rectus sheath block; WI, wound infiltration; SHPB, superior hypogastric plexus block; U/S, ultrasound; N/V, nausea, and vomiting; VAS, Visual analog scale; NRS, numerical rating scale; IV, intravenous; IM, intramuscular; PCA, Patient-controlled analgesia; h, Hour

Supplemental Table 2. *Demographic characteristics of included studies*.

Author year	Groups(n)	Age (yeas)	BMI (kg/m²)	Duration of surgery	ASA I/II/III
Amr 2011(1) Egypt	TAPB before: 23 TAPB after: 23 Control: 22	TAPB before: 53.8 ± 6.1 TAPB after: 51.7 ± 4.5 Control: 50.7 ± 6.5	N/A	TAPB before: 74 ± 19 TAPB after: 73 ± 12 Control: 78 ± 17	TAPB before: 20/3 TAPB after: 19/4 Control: 18/4
Atim 2011(2) Turkey	TAPB: 18 Control: 18 WI: 19	TAPB: 47 (31-63) Control: 44 (30-63) WI: 40 (30-71)	N/A	TAPB: 110.0 (60.0-205.0) Control: 105.0 (55.0-165.0) WI: 90.0 (55.0-180.0)	TAPB: 9/9 Control: 8/10 WI: 10/9
Aytuluk 2020(3) Turkey	SHPB: 30 Control: 30	SHPB 52.4 ± 6.5 Control: 51.6 ± 7.5	SHPB 29.4 ± 4.7 Control 29.4 ± 3.9	SHPB 115.8 ± 34.2 Control 114.2 ± 34.6	SHPB 17/13 Control 16/14
Bhattacharjee 2014(4) India	TAPB: 45 Control: 45	TAPB: 46.1 ± 5.6 Control: 45 ± 6	N/A	TAPB: 92.6 ± 22.1 Control: 90.3 ± 22.0	TAPB: 38/7 Control: 37/8
Carney 2008(5) Ireland	TAPB: 24 Control: 26	TAPB: 50 ± 11 Control: 54 ± 10	TAPB 27 ± 5 Control 26 ± 4	N/A	N/A
Cobby 1996(6) UK	WI: 20 Control: 20	N/A	N/A	N/A	N/A
Erdoğan 2011(7) Turkey	TAPB: 20 Control: 20	TAPB 45 ± 5.8 Control 45 ± 6	N/A	TAPB: 83 ± 17 Control: 74 ± 11.7	N/A
Gasanova 2013(8) USA	TAPB: 25 Control: 25	TAPB: 43.8 ± 6.5 Control 43.1 ± 5.6	TAPB 31.4 ± 6.9 Control 32.8 ± 7.4	TAPB: 186.4 ± 36.3 Control: 179.1 ± 46.0	N/A
Gasanova 2015(9) USA	TAPB: 30 WI: 30	TAPB 43.6 ± 6.4 WI 44.4 ± 6.1	TAPB 31.2 ± 6.7 WI 32.3 ± 6.7	TAPB 189.7 ± 48.0 WI 199.7 ± 50.7	N/A
Gharaei 2013(10) Iran	TAPB: 21 Control: 21	TAPB: 64 Control: 65	N/A	N/A	N/A
Hamed 2019(11) Egypt	ESPB: 30 Control: 30	ESPB: 50.00 ± 5.7 Control: 50.7 ± 4.72	N/A	ESPB: 89.83 ± 19.36 Control: 91.17 ± 20.87	ESPB: 13/14/3 Control: 14/12/4
Hariharan 2009(12) Barbados	WI: 20 Control: 20	WI 44.5 ± 5.9 Control 44.8 ± 6	N/A	WI 1.73 ± 0.55 Control 1.57 ± 0.43	N/A
Hayden 2017(13) Sweden	WI: 29 Control: 28	WI: 46 (45–50) Control: 47 (46–51)	WI: 26 (24–29) Control: 25 (23–33)	WI: 130 (120–150) Control: 140 (120–180)	WI: 21/8 Control: 17/11
Ismail 2021(14) Pakistan	TAPB: 25 Control: 25	TAPB: 45.0 ± 7.94 Control: 47.08 ± 7.59	TAPB:28.21 ± 4.29 Control: 28.19 ± 5.67	TAPB:141 ± 21 Control: 168 ± 37.8	TAPB: 4/21 Control: 10/15
Jarruwale 2016(15) Thailand	WI: 31 Control: 31	WI 45.87 ± 4.25 Control 44.84 ± 4.52	N/A	WI 120 (75-325) Control 125 (85-245)	N/A
Kamel 2020(16) Egypt	TAPB: 24 ESPB: 24	TAPB: 56.4 ± 5.9 ESPB: 53.7 ± 6.5	TAPB: 24.1 ± 3.84 ESPB: 23.13 ± 4.24	TAPB: 109.32 ± 34.82 ESPB: 118.36 ± 38.21	TAPB: 17/7 ESPB: 16/8
Karaman 2018(17) Turkey	TAPB: 34 Control: 32	TAPB: 46.6 ± 4.6 Control: 48.9 ± 4.7	TAPB: 28.5 ± 4.7 Control: 29.5 ± 4.4	TAPB: 136.62 ± 35.7 Control: 125.00 ± 32.5	TAPB: 20/14 Control: 16/16
Kelly 1996(18) Ireland	IINB: 20 Control: 20	N/A	N/A	N/A	N/A
Klein 2000(19) UK	WI: 20 Control: 20	WI 41.4 (28-51) Control 40.3 (32-52)	N/A	WI 44.1 ± 15.5 Control 48.0 ± 16.3	N/A
Lowenstein 2008(20) Israel	WI: 16 Control: 14	WI 48.8 ± 4.8 Control 46.4 ± 9.13	N/A	WI 107.8 ± 22.8 Control 111.7 ± 24.3	N/A
Marais 2014(21) South Africa	TAPB: 15 Control: 15	TAPB: 46.6 ± 4.7 Control 48 ± 6.7	TAPB 25 ± 5.3 Control 27.9 ± 6.6	N/A	N/A
Mathew 2019(22) India	TAPB: 20 Control: 20	TAPB: 45.5 ± 6.7 Control: 46.7 ± 5.4	TAPB: 24.4 ± 3.2 Control: 24.6 ± 3.2	N/A	TAPB: 16/4 Control: 18/2

Supplemental Table 2 (continued). *Demographic characteristics of included studies*.

Author year	Groups(n)	Age (yeas)	BMI (kg/m²)	Duration of surgery	ASA I/II/III
Mishra 2022(23) India	WI (pre-incision): 30 WI (post-closure): 30 Control: 30	N/A	N/A	N/A	N/A
Mohammad 2019(24) Egypt	TAPB: 30 RSB: 30	TAPB: 46.67 ± 4.6 RSB: 46.47 ± 5.21	N/A	TAPB: 88.5 ± 8.36 RSB: 87.17 ± 9.34	N/A
Moyo 2016(25) Zimbabwe	TAPB: 16 Control: 16	TAPB: 40.7 ± 6.8 Control: 46.5 ± 6.9	TAPB: 24.3 ± 3.8 Control: 24.3 ± 3.9	N/A	TAPB: 8/7/1 Control: 4/9/3
Naaz 2021(26) India	QLB: 25 TAPB: 26 Control: 25	QLB: 43.6 ± 8.54 TAPB: 43.96 ± 6.44 Control: 42.52 ± 8.267	QLB: 23.51 ± 2.02 TAPB: 23.41 ± 1.47 Control: 23.15 ± 1.28	N/A	QLB: 20/5 TAPB:19/7 Control: 17/8
Prasad 2021(27) India	ESPB: 28 Control: 30	ESPB: 47.89 ± 6.37 Control: 51.1 ± 7.85	ESPB: 21.78 ± 0.74 Control: 22.43 ± 1.26	ESPB: 108.39 ± 9.73 Control: 108.83 ± 8.98	N/A
Rapp 2016(28) Sweden	SHPB: 35 Control: 33	SHPB 46.0 (35–63) Control 45.5(34-69)	N/A	N/A	N/A
Røjskjær 2015(29) Denmark	TAPB: 24 Control: 24	TAPB 49 ± 8 Control 47 ± 7	TAPB: 28 ± 6 Control 25 ± 5	TAPB: 91 ± 28 Control: 85 ± 25	TAPB: 13/10/0 Control 16/6/1
Shah 2012(30) Singapore	RSB: 21 WI: 21	RSB: 45.0 ± 7.2 WI: 43.2 ± 7.7	N/A	RSB: 91.8 ± 28.8 WI: 86.5 ± 24.0	RSB: 16/5 WI: 15/6
Shukula 2021(31)	QLB: 35 TAPB: 35 Control: 35	QLB: 42.54 ± 5.11 TAPB: 42.80 ± 5.83 Control: 41.69 ± 7.52	QLB: 23.64 ± 1.98 TAPB: 23.52 ± 1.46 Control: 23.23 ± 1.21	QLB:104.43 ± 17.05 TAPB:103.14 ± 15.43 Control:103.71 ± 16.05	QLB: 28/7 TAPB: 27/8 Control: 25/10
Sinclair 1996(32) Sweden	WI: 15 Control: 15	WI 44 ± 6.6 Control 43 ± 7.9	WI 65 ± 17.7 Control 67 ± 15.6	WI 93 ± 8.8 Control 96 ± 5.1	N/A
Suner 2019(33) Turkey	TAPB: 25 Control: 25	TAPB: 48.9±7.9 Control:50.6±6.0	TAPB:25.8±3.3 Control: 27.3±2.8	N/A	TAPB: 2/22/1 Control: 2/23/0
Victory 1995(34) USA	WI: 19 Control: 19	WI 36 ± 6 Control 35 ± 8	WI 32 ± 6 Control 30 ± 5	N/A	N/A
Yousef 2018(35) Egypt	TAPB: 30 QLB: 30	TAPB: 50.7 ± 6.8 QLB: 56.5 ± 6.97	N/A	TAPB: 122 ± 42 QLB: 107 ± 40	TAPB: 20/10 QLB: 19/11
Yucel 2013(36) Turkey	IINB: 19 Control: 22	IINB: 47.2 ± 7.9 Control: 44.8 ± 12.0	N/A	IINB: 83.3 ± 19.7 Control: 75.6 ± 18.9	IINB: 6/13 Control: 7/15

Abbreviation: TAPB, transversus abdominis plane block; QLB, quadratus lumborum block; ESPB, erector spinae plane block; IINB, ilioinguinal-iliohypogastric nerve block; RSB, rectus sheath block; U/S, ultrasound; N/A, not available

Supplemental Table 3. *Risk of Bias 2.0 assessment of included RCTs.*

Author/Year	Bias due to					Overall bias
	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported results	
Total 24-hour morphine consumption						
Atim 2011(2)	Low	Low	Low	Low	Some concernsb	Some concerns
Carney 2008(5)	Low	Low	Low	Low	Some concernsb	Some concerns
Cobby 1996(6)	Some concernsa	Low	Low	Low	Some concernsb	Some concerns
Gasanova 2013(8)	Low	Low	Low	Low	Low	Low
Gasanova 2015(9)	Low	Low	Low	Low	Low	Low
Hamed 2019(11)	Low	Low	Low	Low	Low	Low
Hariharan 2009(12)	Some concernsa	Low	Low	Low	Some concernsb	Some concerns
Hayden 2017(13)	Low	Low	Low	Low	Low	Low
Ismail 2021(14)	Low	Low	Low	Low	Low	Low
Kamel 2020(16)	Some concernsa	Low	Low	Low	Low	Some concerns
Klein 2000(19)	Some concernsa	Low	Low	Low	Some concernsb	Some concerns
Marais 2014(21)	Low	Low	Low	Low	Low	Low
Mathew 2019(22)	Low	Low	Low	Low	Low	Low
Mohammad 2019(24)	Low	Low	Low	Low	Some concernsb	Some concerns
Prasad 2021(27)	Some concernsa	Low	Low	Low	Low	Some concerns
Røjskjær 2015(29)	Low	Low	Low	Low	Low	Low
Shah 2012(30)	Low	Low	Low	Low	Low	Low
Suner 2019(33)	Low	Low	Low	Low	Some concernsb	Some concerns
Victory 1995(34)	Low	Low	Low	Low	Some concernsb	Some concerns
Yousef 2018(35)	Low	Low	Low	Low	Some concernsb	Some concerns
Time to first rescue analgesia						
Amr 2011(1)	Low	Low	Low	Low	Some concernsb	Some concerns
Bhattacharjee 2014(4)	Low	Low	Low	Low	Some concernsb	Some concerns
Carney 2008(5)	Low	Low	Low	Low	Some concernsb	Some concerns
Erdoğan 2011(7)	Some concernsa	Low	Low	Low	Some concernsb	Some concerns
Hayden 2017(13)	Low	Low	Low	Low	Low	Low
Kamel 2020(16)	Some concernsa	Low	Low	Low	Low	Some concerns
Mathew 2019(22)	Low	Low	Low	Low	Low	Low
Mohammad 2019(24)	Low	Low	Low	Low	Some concernsb	Some concerns
Moyo 2016(25)	Some concernsa	Low	Low	Low	Low	Some concerns
Naaz 2021(26)	Low	Low	Low	Low	Low	Low
Prasad 2021(27)	Some concernsa	Low	Low	Low	Low	Some concerns
Shukula 2021(31)	Low	Low	Low	Low	Some concernsb	Some concerns
Suner 2019(33)	Low	Low	Low	Low	Some concernsb	Some concerns
Yousef 2018(35)	Low	Low	Low	Low	Some concernsb	Some concerns
Postoperative pain scores (6-8h)						
Amr 2011(1)	Low	Low	Low	Low	Some concernsb	Some concerns
Atim 2011(2)	Low	Low	Low	Low	Some concernsb	Some concerns
Carney 2008(5)	Low	Low	Low	Low	Some concernsb	Some concerns

Supplemental Table 3 (continued). *Risk of Bias 2.0 assessment of included RCTs.*

Author/Year	Bias due to					Overall bias
	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported results	
Gharaei 2013(10)	Low	Low	Low	Low	Low	Low
Hamed 2019(11)	Low	Low	Low	Low	Low	Low
Karaman 2018(17)	Low	Low	Low	Low	Low	Low
Lowenstein 2008(20)	Low	Low	Low	Low	Some concernsb	Some concerns
Marais 2014(21)	Low	Low	Low	Low	Low	Low
Mathew 2019(22)	Low	Low	Low	Low	Low	Low
Mohammad 2019(24)	Low	Low	Low	Low	Some concernsb	Some concerns
Prasad 2021(27)	Some concernsa	Low	Low	Low	Low	Some concerns
Røjskjær 2015(29)	Low	Low	Low	Low	Low	Low
Shukula 2021(31)	Low	Low	Low	Low	Some concernsb	Some concerns
Sinclair 1996(32)	Some concernsa	Low	Low	Low	Some concernsb	Some concerns
Suner 2019(33)	Low	Low	Low	Low	Some concernsb	Some concerns
Yousef 2018(35)	Low	Low	Low	Low	Some concernsb	Some concerns
Postoperative pain scores (24h)						
Amr 2011(1)	Low	Low	Low	Low	Some concernsb	Some concerns
Atim 2011(2)	Low	Low	Low	Low	Some concernsb	Some concerns
Carney 2008(5)	Low	Low	Low	Low	Some concernsb	Some concerns
Gasanova 2013(8)	Low	Low	Low	Low	Low	Low
Gharaei 2013(10)	Low	Low	Low	Low	Low	Low
Hamed 2019(11)	Low	Low	Low	Low	Low	Low
Karaman 2018(17)	Low	Low	Low	Low	Low	Low
Marais 2014(21)	Low	Low	Low	Low	Low	Low
Mathew 2019(22)	Low	Low	Low	Low	Low	Low
Prasad 2021(27)	Some concernsa	Low	Low	Low	Low	Some concerns
Røjskjær 2015(29)	Low	Low	Low	Low	Low	Low
Shukula 2021(31)	Low	Low	Low	Low	Some concernsb	Some concerns
Suner 2019(33)	Low	Low	Low	Low	Some concernsb	Some concerns
Yousef 2018(35)	Low	Low	Low	Low	Some concernsb	Some concerns
Incidence of nausea and vomiting						
Amr 2011(1)	Low	Low	Low	Low	Some concernsb	Some concerns
Bhattacharjee 2014(4)	Low	Low	Low	Low	Some concernsb	Some concerns
Carney 2008(5)	Low	Low	Low	Low	Some concernsb	Some concerns
Erdoğan 2011(7)	Some concernsa	Low	Low	Low	Some concernsb	Some concerns
Gasanova 2013(8)	Low	Low	Low	Low	Low	Low
Gasanova 2015(9)	Low	Low	Low	Low	Low	Low
Gharaei 2013(10)	Low	Low	Low	Low	Low	Low
Hayden 2017(13)	Low	Low	Low	Low	Low	Low
Kamel 2020(16)	Some concernsa	Low	Low	Low	Low	Some concerns
Marais 2014(21)	Low	Low	Low	Low	Low	Low
Mathew 2019(22)	Low	Low	Low	Low	Low	Low

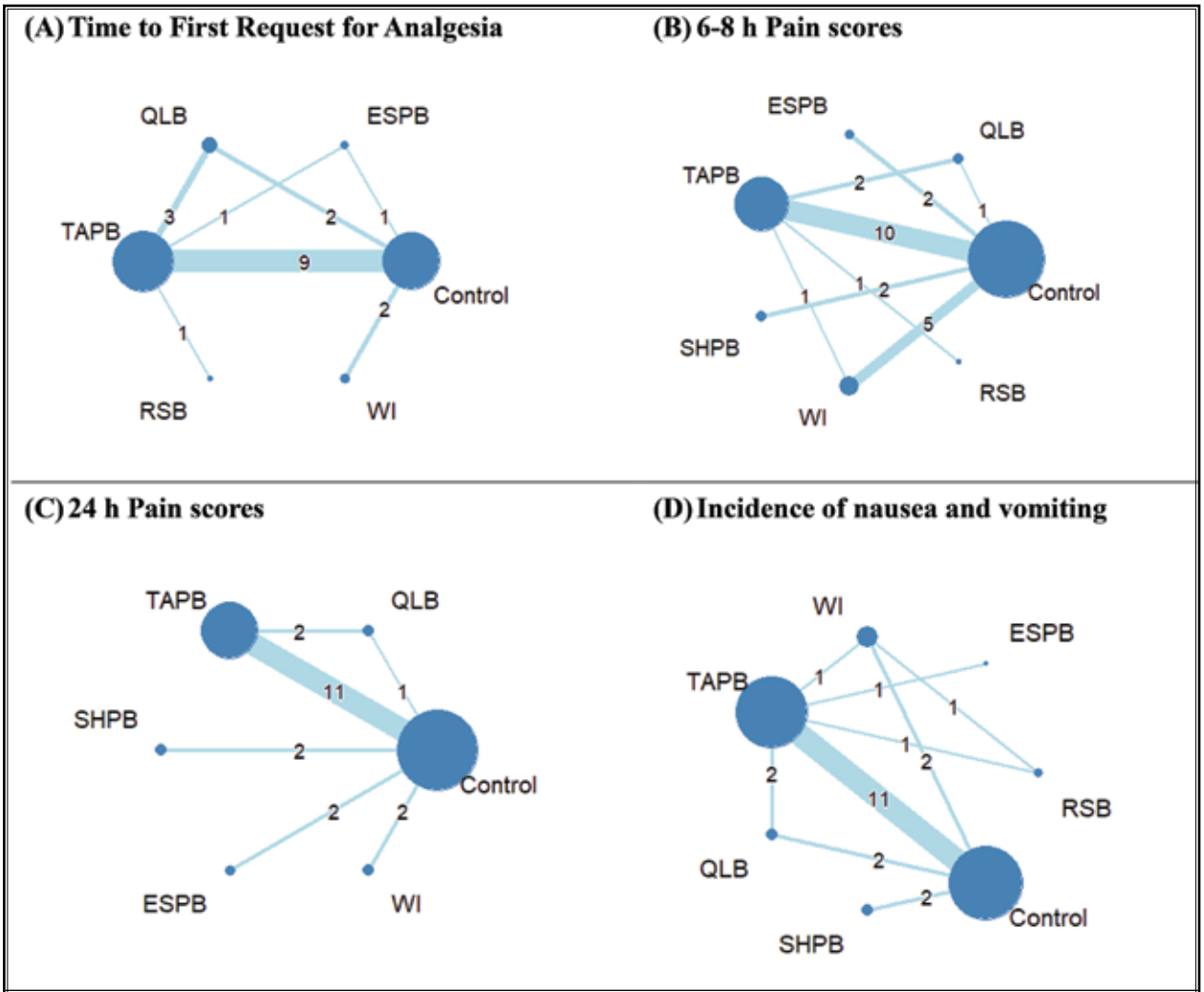
Supplemental Table 3 (continued). *Risk of Bias 2.0 assessment of included RCTs.*

Author/Year	Bias due to					Overall bias
	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of the outcome	Selection of the reported results	
Mohammad 2019(24)	Low	Low	Low	Low	Some concernsb	Some concerns
Naaz 2021(26)	Low	Low	Low	Low	Low	Low
Shah 2012(30)	Low	Low	Low	Low	Low	Low
Shukula 2021(31)	Low	Low	Low	Low	Some concernsb	Some concerns
Suner 2019(33)	Low	Low	Low	Low	Some concernsb	Some concerns

RCTs, randomized controlled trials.
No information about allocation sequence, but no baseline imbalance was observed.
No result selected from multiple outcome measurements, but no information about pre-specified plan.

Supplemental Table 4. *Confidence in Network Meta-Analysis (CINeMA) for total 24 h morphine consumption.*

Comparison	Number of studies	Within-study bias	Indirectness	Imprecision	Heterogeneity	Incoherence	Confidence rating
Control:ESPB	2	Some concerns	No concerns	No concerns	Major concerns	No concerns	Very low
Control:TAPB	8	No concerns	No concerns	No concerns	Major concerns	No concerns	Low
Control:WI	6	Some concerns	No concerns	No concerns	Major concerns	No concerns	Very low
ESPB:TAPB	1	Some concerns	No concerns	Some concerns	Some concerns	No concerns	Very low
QLB:TAPB	1	Some concerns	No concerns	Major concerns	No concerns	No concerns	Very low
RSB:TAPB	1	Some concerns	No concerns	Major concerns	No concerns	No concerns	Very low
RSB:WI	1	No concerns	No concerns	Major concerns	No concerns	No concerns	Low
TAPB:WI	1	Some concerns	No concerns	Major concerns	No concerns	No concerns	Very low
Control:QLB	0	Some concerns	No concerns	Some concerns	Some concerns	No concerns	Very low
Control:RSB	0	Some concerns	No concerns	Major concerns	No concerns	No concerns	Very low
ESPB:QLB	0	Some concerns	No concerns	Major concerns	No concerns	No concerns	Very low
ESPB:RSB	0	Some concerns	No concerns	Some concerns	Some concerns	No concerns	Very low
ESPB:WI	0	Some concerns	No concerns	Major concerns	No concerns	No concerns	Very low
QLB:RSB	0	Some concerns	No concerns	Major concerns	No concerns	No concerns	Very low
QLB:WI	0	Some concerns	No concerns	Major concerns	No concerns	No concerns	Very low



Supplemental Fig. 1. *Network plots for the secondary outcome.*

Random effects model:

comparison	k	prop	nma	direct	indir.	Diff	z	p-value
ESPB:Control	2	0.69	-11.5704	-13.4848	-7.2600	-6.2249	-0.66	0.5123
QLB:Control	0	0	-10.9117	.	-10.9117	.	.	.
RSB:Control	0	0	-1.9937	.	-1.9937	.	.	.
TAPB:Control	8	0.80	-6.5117	-6.3040	-7.3565	1.0525	0.16	0.8757
WI:Control	7	0.85	-6.2344	-5.5402	-10.1666	4.6265	0.55	0.5816
ESPB:QLB	0	0	-0.6587	.	-0.6587	.	.	.
ESPB:RSB	0	0	-9.5767	.	-9.5767	.	.	.
ESPB:TAPB	1	0.39	-5.0587	-1.2900	-7.5149	6.2249	0.66	0.5123
ESPB:WI	0	0	-5.3360	.	-5.3360	.	.	.
QLB:RSB	0	0	-8.9180	.	-8.9180	.	.	.
QLB:TAPB	1	1.00	-4.4000	-4.4000	.	.	.	.
QLB:WI	0	0	-4.6773	.	-4.6773	.	.	.
RSB:TAPB	1	0.67	4.5180	6.3600	0.8176	5.5424	0.43	0.6687
RSB:WI	1	0.42	4.2407	1.0000	6.5424	-5.5424	-0.43	0.6687
TAPB:WI	2	0.34	-0.2773	1.1674	-1.0281	2.1955	0.29	0.7706

Supplemental Fig. 2. *Netsplit of total 24-hour morphine consumption*

Random effects model:

comparison	k	prop	nma	direct	indir.	Diff	z	p-value
ESPB:Control	1	0.58	10.5853	13.6800	6.3365	7.3435	2.98	0.0029
QLB:Control	2	0.66	6.6993	6.6334	6.8274	-0.1940	-0.10	0.9199
RSB:Control	0	0	0.3896	.	0.3896	.	.	.
TAPB:Control	9	0.94	2.4496	2.2158	5.9121	-3.6962	-1.73	0.0839
WI:Control	2	1.00	0.6903	0.6903	.	.	.	.
ESPB:QLB	0	0	3.8860	.	3.8860	.	.	.
ESPB:RSB	0	0	10.1957	.	10.1957	.	.	.
ESPB:TAPB	1	0.47	8.1357	4.2300	11.5735	-7.3435	-2.98	0.0029
ESPB:WI	0	0	9.8950	.	9.8950	.	.	.
QLB:RSB	0	0	6.3097	.	6.3097	.	.	.
QLB:TAPB	3	0.85	4.2497	3.9318	6.0922	-2.1603	-0.87	0.3843
QLB:WI	0	0	6.0090	.	6.0090	.	.	.
RSB:TAPB	1	1.00	-2.0600	-2.0600	.	.	.	.
RSB:WI	0	0	-0.3007	.	-0.3007	.	.	.
TAPB:WI	0	0	1.7593	.	1.7593	.	.	.

Supplemental Fig. 3. *Netsplit of Time to first request for analgesia*.

Random effects model:

comparison	k	prop	nma	direct	indir.	Diff	z	p-value
ESPB:Control	2	1.00	-1.2045	-1.2045	.	.	.	.
QLB:Control	1	0.49	-3.1196	-2.4890	-3.7358	1.2468	1.16	0.2466
RSB:Control	0	0	-0.0842	.	-0.0842	.	.	.
SHPB:Control	2	1.00	-0.8301	-0.8301	.	.	.	.
TAPB:Control	10	0.96	-0.9536	-0.9843	-0.1233	-0.8610	-0.66	0.5081
WI:Control	5	0.94	-0.2357	-0.3566	1.8042	-2.1608	-1.47	0.1409
ESPB:QLB	0	0	1.9151	.	1.9151	.	.	.
ESPB:RSB	0	0	-1.1203	.	-1.1203	.	.	.
ESPB:SHPB	0	0	-0.3744	.	-0.3744	.	.	.
ESPB:TAPB	0	0	-0.2509	.	-0.2509	.	.	.
ESPB:WI	0	0	-0.9687	.	-0.9687	.	.	.
QLB:RSB	0	0	-3.0354	.	-3.0354	.	.	.
QLB:SHPB	0	0	-2.2895	.	-2.2895	.	.	.
QLB:TAPB	2	0.88	-2.1660	-2.2849	-1.3064	-0.9786	-0.62	0.5344
QLB:WI	0	0	-2.8839	.	-2.8839	.	.	.
RSB:SHPB	0	0	0.7459	.	0.7459	.	.	.
RSB:TAPB	1	1.00	0.8694	0.8694	.	.	.	.
RSB:WI	0	0	0.1515	.	0.1515	.	.	.
SHPB:TAPB	0	0	0.1235	.	0.1235	.	.	.
SHPB:WI	0	0	-0.5944	.	-0.5944	.	.	.
TAPB:WI	1	0.25	-0.7179	-1.4379	-0.4753	-0.9627	-1.05	0.2927

Supplemental Fig. 4. *Netsplit of postoperative pain score (6-8h)*.

Random effects model:

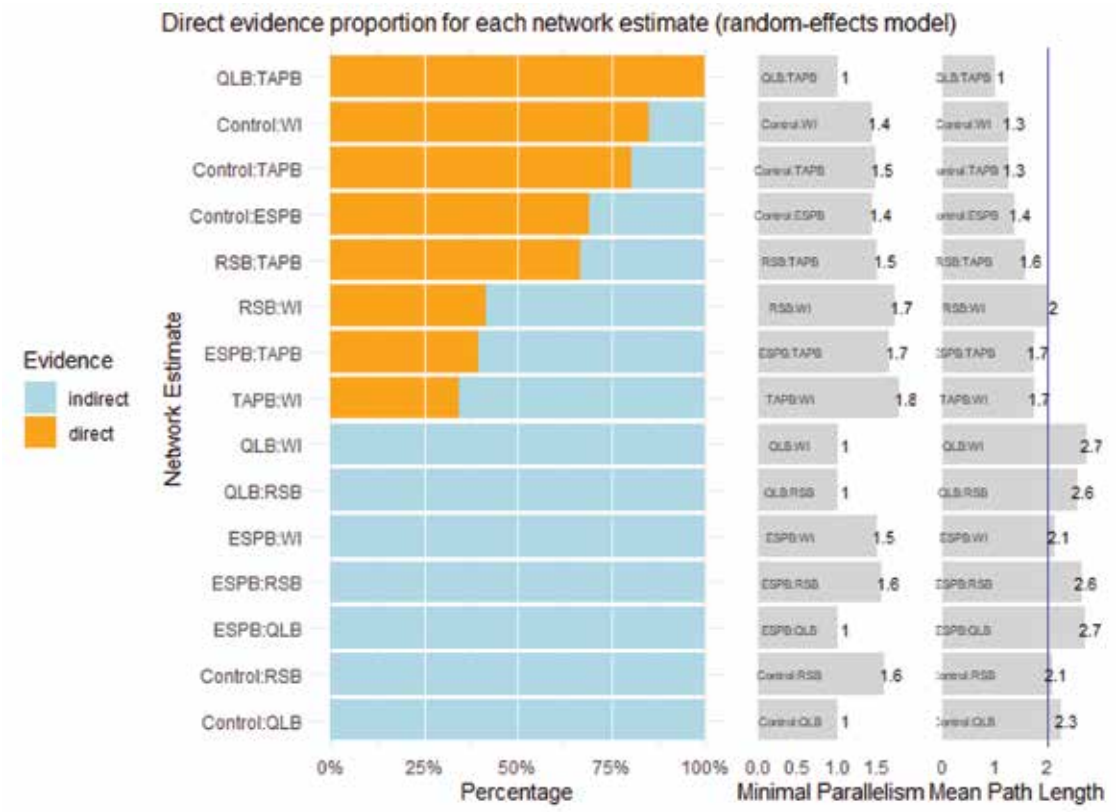
comparison	k	prop	nma	direct	indir.	Diff	z	p-value
ESPB:Control	2	1.00	-0.3342	-0.3342	.	.	.	.
QLB:Control	1	0.49	-2.3744	-0.9829	-3.7255	2.7426	1.97	0.0485
SHPB:Control	2	1.00	-0.4391	-0.4391	.	.	.	.
TAPB:Control	11	0.99	-0.8820	-0.9651	5.6463	-6.6113	-2.43	0.0153
WI:Control	2	1.00	-0.2684	-0.2684	.	.	.	.
ESPB:QLB	0	0	2.0401	.	2.0401	.	.	.
ESPB:SHPB	0	0	0.1049	.	0.1049	.	.	.
ESPB:TAPB	0	0	0.5478	.	0.5478	.	.	.
ESPB:WI	0	0	-0.0658	.	-0.0658	.	.	.
QLB:SHPB	0	0	-1.9353	.	-1.9353	.	.	.
QLB:TAPB	2	0.87	-1.4924	-1.7618	0.2749	-2.0367	-1.03	0.3013
QLB:WI	0	0	-2.1059	.	-2.1059	.	.	.
SHPB:TAPB	0	0	0.4429	.	0.4429	.	.	.
SHPB:WI	0	0	-0.1706	.	-0.1706	.	.	.
TAPB:WI	0	0	-0.6136	.	-0.6136	.	.	.

Supplemental Fig. 5. *Netsplit of postoperative pain score (24h).*

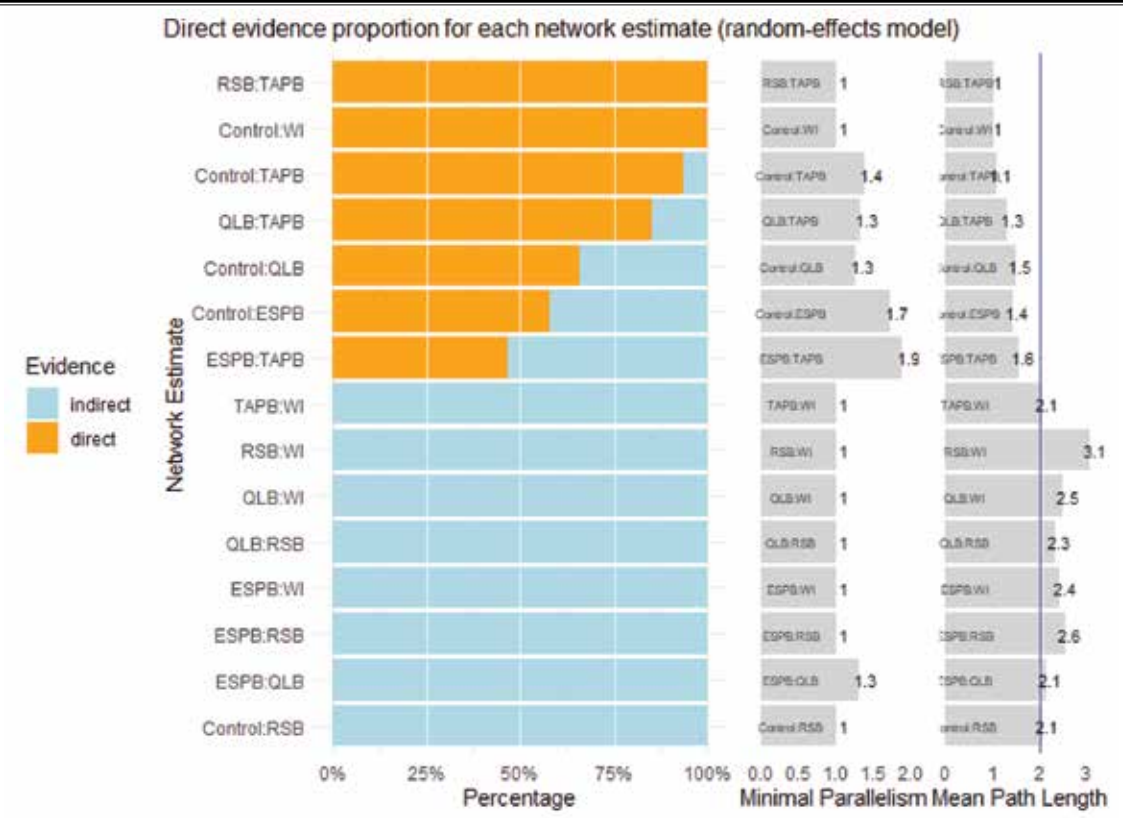
Random effects model:

comparison	k	prop	nma	direct	indir.	RoR	z	p-value
ESPB:Control	0	0	0.1670	.	0.1670	.	.	.
QLB:Control	2	0.53	0.9489	2.6145	0.3004	8.7021	1.72	0.0855
RSB:Control	0	0	3.4813	.	3.4813	.	.	.
SHPB:Control	2	1.00	0.9759	0.9759	.	.	.	.
TAPB:Control	11	0.91	0.6123	0.5988	0.7772	0.7704	-0.34	0.7310
WI:Control	2	0.71	0.4994	0.5392	0.4154	1.2980	0.34	0.7312
ESPB:QLB	0	0	0.1760	.	0.1760	.	.	.
ESPB:RSB	0	0	0.0480	.	0.0480	.	.	.
ESPB:SHPB	0	0	0.1711	.	0.1711	.	.	.
ESPB:TAPB	1	1.00	0.2727	0.2727	.	.	.	.
ESPB:WI	0	0	0.3344	.	0.3344	.	.	.
QLB:RSB	0	0	0.2726	.	0.2726	.	.	.
QLB:SHPB	0	0	0.9724	.	0.9724	.	.	.
QLB:TAPB	2	0.86	1.5498	1.0173	21.3423	0.0477	-1.71	0.0865
QLB:WI	0	0	1.9000	.	1.9000	.	.	.
RSB:SHPB	0	0	3.5673	.	3.5673	.	.	.
RSB:TAPB	1	0.57	5.6856	10.5455	2.5266	4.1738	0.86	0.3921
RSB:WI	1	0.48	6.9705	3.3333	13.9128	0.2396	-0.86	0.3921
SHPB:TAPB	0	0	1.5938	.	1.5938	.	.	.
SHPB:WI	0	0	1.9540	.	1.9540	.	.	.
TAPB:WI	1	0.33	1.2260	1.8286	1.0090	1.8123	0.76	0.4488

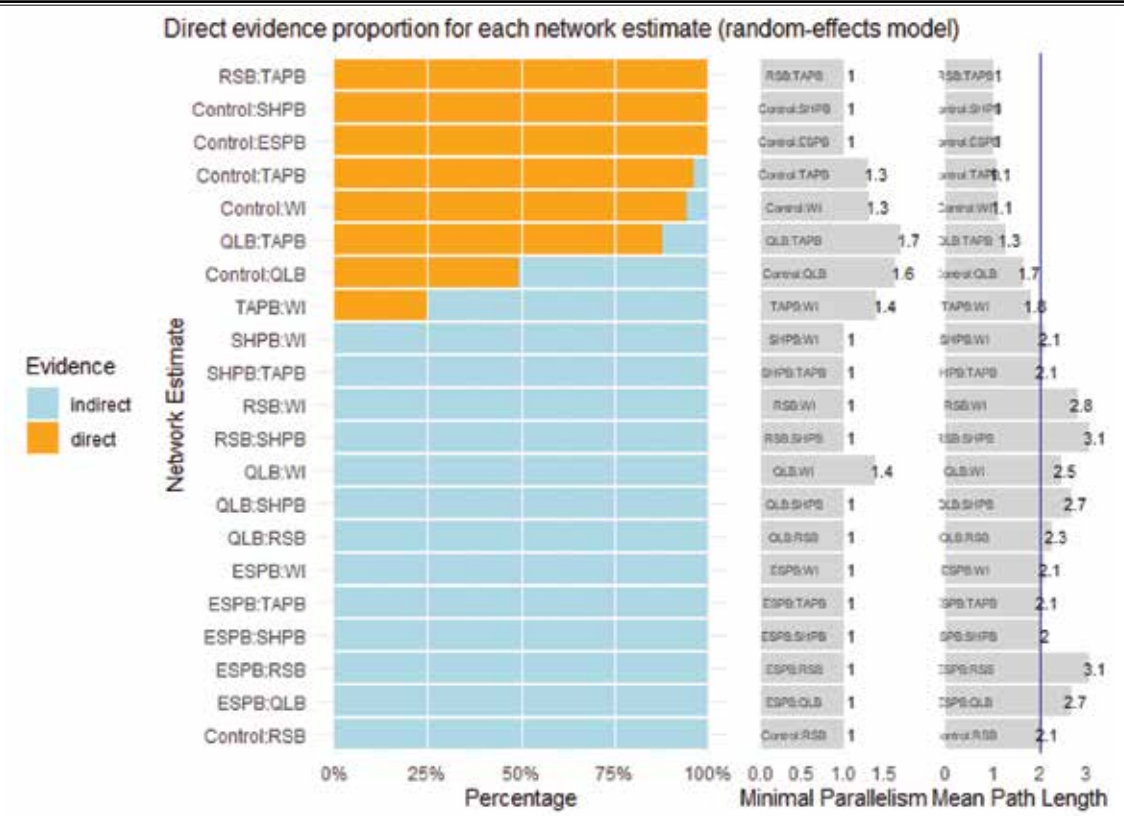
Supplemental Fig. 6. *Netsplit of incidence of nausea and vomiting.*



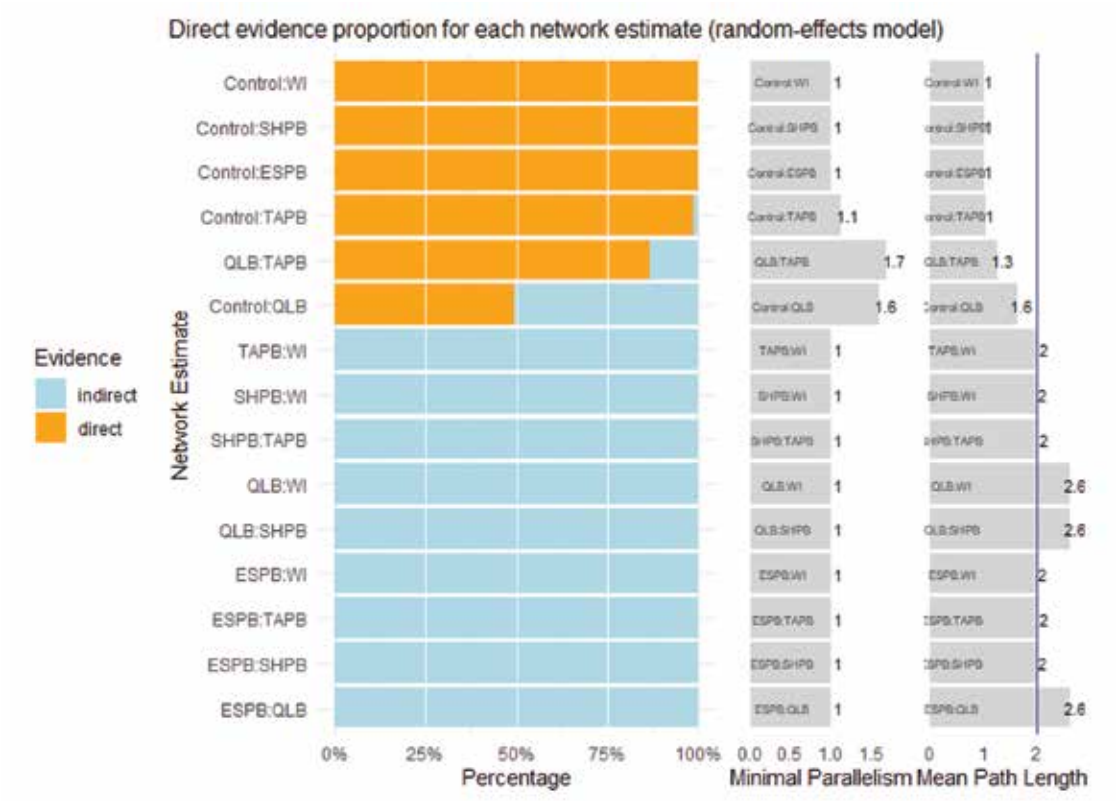
Supplemental Fig. 7. ***Direct evidence proportion for total 24-hour morphine consumption.***



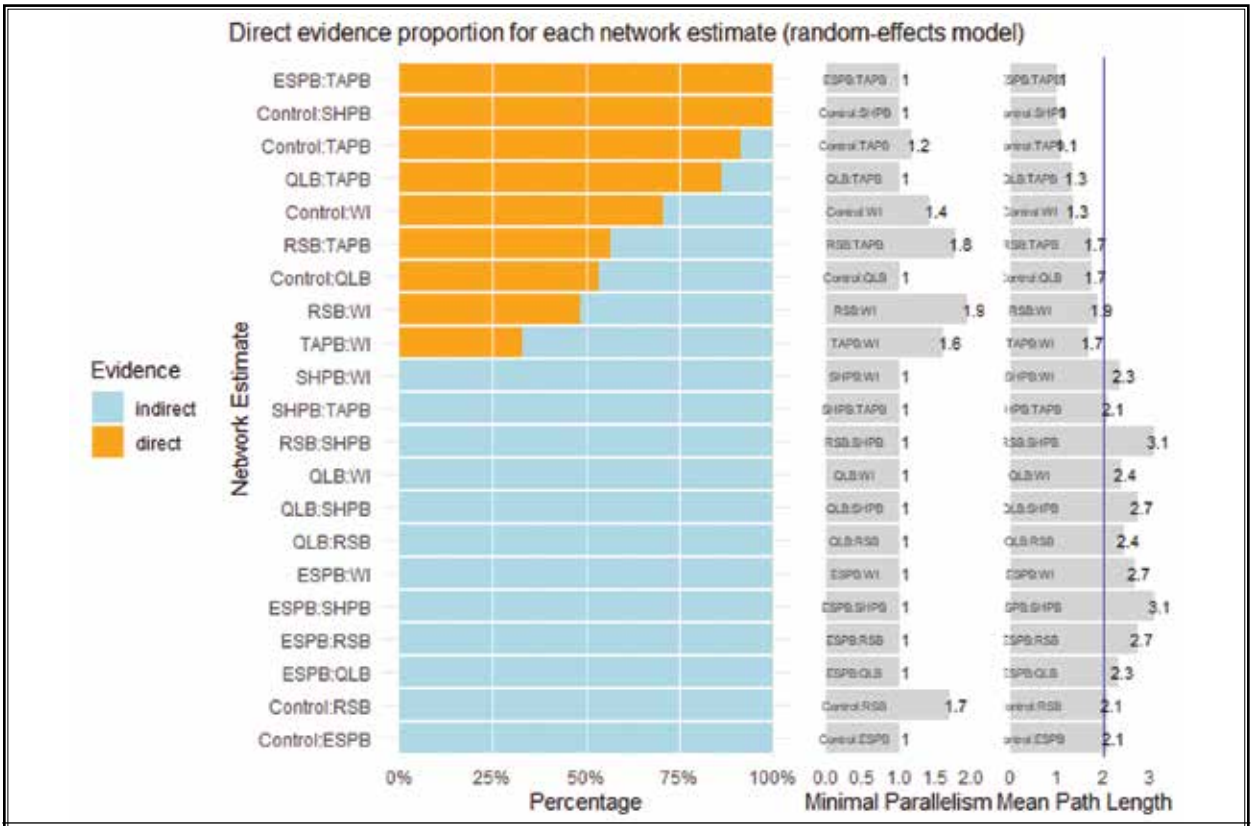
Supplemental Fig. 8. *Direct evidence proportion for time to first request for analgesia.*



Supplemental Fig. 9. *Direct evidence proportion for postoperative pain score (6-8h)*.



Supplemental Fig. 10. *Direct evidence proportion for postoperative pain score (24h)*.



Supplemental Fig. 11. *Direct evidence proportion for incidence of nausea and vomiting.*

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